July 21, 2003
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A Technical Interchange Meeting (TIM) was held between the GLAST Project Mission Operations personnel and GBM IOC personnel on May 2nd ,2003, after the GBM IOC PDR. This memo summarizes the outcome of the meeting. Where appropriate, there are a few notes to bring the topic up-to-date, etc. from Mike Rackley. These comments are in brackets and italics, and start with "Post-mtg note". The following persons were in attendance for part or all of the proceedings.

GBM:
Bill Paciesas, Rob Preece, Chip Meegan, Michael Briggs

GLAST Project:
Mike Rackley, Erik Andrews, Ernest Canevari, John Nagy, Ross Cox, Bruce Wagner (via telecon)

Instrument Commanding

There was a detailed discussion of the exact methods by which each element of the ground system involved in GBM planning and commanding (GBM IOC, SSC and MOC), would interact to successfully command the instrument. The discussions covered real-time and non-real-time/stored commanding. They did not address what happens in an anomalous situation. That will be addressed at a later date.

Nominally instrument commands from the IOC will go to the SSC, which will perform science-oriented constraint checking. The SSC will send accepted instrument commands on to the MOC, which will perform command-oriented constraint checking (e.g., ensuring max allowed number of commands per second not exceeded). An example was discussed: GBM IOC requests to put the instrument into a mode that would cause it to trigger more frequently (e.g., raising the trigger threshold). But the SSC sees that this would potentially interfere with something the LAT IOC wanted LAT to do, or with an approved request from a guest investigator. The conflict could be with conducting the on-board science, with the amount of data that would or might go the recorder for the time period in question, etc. The SSC will work these conflicts with the users until a compatible observation timeline is achieved, and then pass it on to the MOC.

It was agreed that we also need to be able to get commands directly from the IOC to the MOC for test support and contingency operations. *[Post mtg note: We also need this to support L&EO, since we will not be going through the SSC during this period.]* We agreed that we would try to keep the format of the data going to the MOC the same or very similar regardless of whether it is coming from the IOC or SSC to facilitate this.

It was agreed that the GBM IOC will need to send some type of urgency indicator to the SSC. The urgency indicator will tell the SSC whether or not to verify the request against the current (or applicable) science timeline. If the SSC finds a difficulty in the impact of processing the request from the IOC then the SSC will reject the request by sending an indication back to the IOC with the reason why the rejection occurred. If the request does not conflict with the science mission, it will be forwarded to the MOC. The MOC will always check the request against the applicable mission timeline for conflict with engineering activities. It is expected that the observatory will require very little weekly or daily engineering activity. If the MOC determines the request will not adversely impact the mission, it notifies the SSC that it will be honored. Otherwise a notification is sent back to the SSC indicating the problem. The SSC will then coordinate with IOC and MOC personnel as appropriate to resolve the problem.

It was agreed that the command-related files being exchanged among the 3 elements would be ASCII files. The exact formats will be defined in the ICD's.

The nature of a command request was discussed and it was determined that a request for instrument commanding could potentially be one of the five forms below:

1) a command PROC that would exist in the MOC as a predefined, validated, and controlled ops PROC;
2) a request for the FOT to execute an existing GBM command PROC at some later time (e.g., that ops day),with associated command parameters;
3) a real-time (RT) command sequence, which is a series of instrument command mnemonics that would get put into a command PROC and executed;
4) an instrument command load that contains instrument command mnemonics that would get incorporated into the Absolute Time Sequence (ATS) load being built by the MOC
5) an instrument memory load that contains bits to be loaded directly to the instrument by the MOC (e.g., instrument table)

These are depicted below in Figure 1 – GBM Commanding Flow.

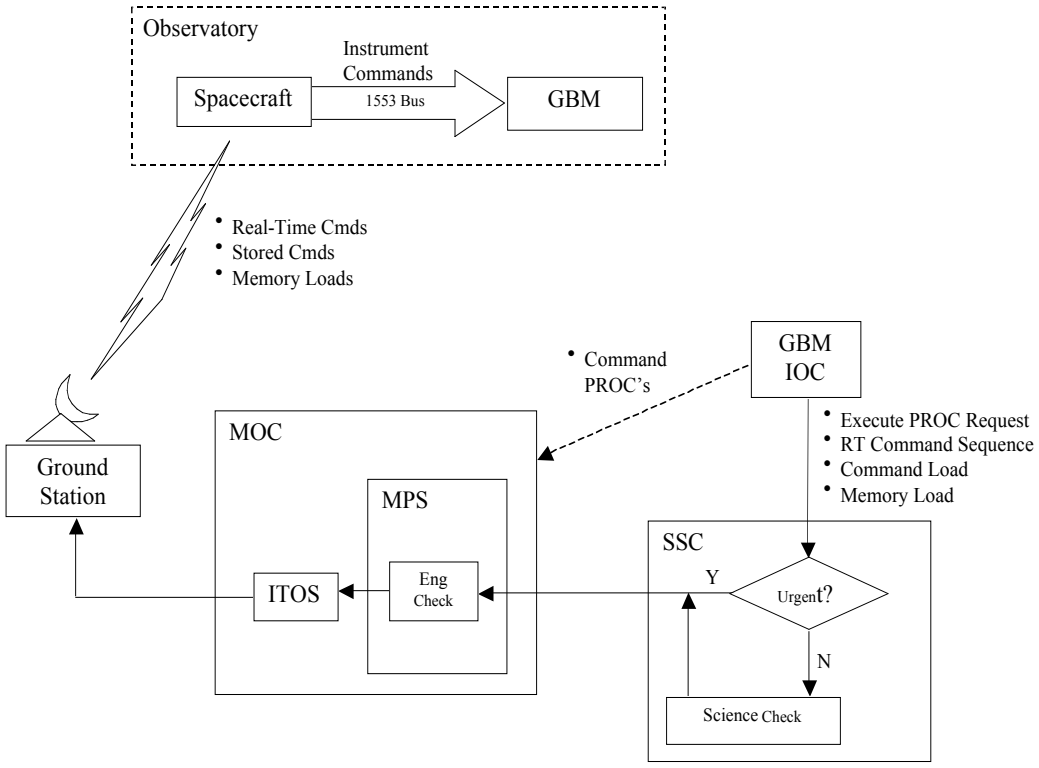

Figure 1 – GBM Commanding Flow

(1) Command PROC's

Command PROC's are generally used for sending commands that are executed upon receipt by the observatory, referred to as real-time (RT) commands. They only execute in the MOC, and are based on the ITOS Systems Test and Operations Language (STOL). They generally are prevalidated and reside in a MOC configuration-controlled environment. The FOT executes them

as needed for real-time commanding. Command PROC's can also contain waits, checks on telemetry values, logic (e.g., IF-THEN-ELSE constructs and loops), etc.

It was agreed that the GBM Team will be responsible for documenting the procedures needed for the instrument and delivering these to the FOT. These are procedures that describe what commands need to be sent to the instrument, what telemetry should be monitored, what prerequisite conditions exist for the commands, how the command execution is verified, etc. They are not the actual ITOS PROC's executed in the MOC.

GBM Team agreed to also provide the FOT with the AstroRT PROC's generated and used for instrument and observatory I&T to help in the development of GBM instrument operations PROC's.

The FOT agreed to generate the actual GBM instrument command PROC's, with help from the GBM Team, using the provided written procedures and AstroRT I&T PROC's. While the FOT can perform some initial validation of the PROC's (e.g., syntax completeness), the GBM Team is responsible for participating in the process of validating that the PROC's actually accomplish what is intended with the instrument. The GBM Team will have to sign off on all GBM PROC's before they can be used with the instrument. Operationally the FOT will execute the PROC's in the MOC when needed.

With this type of commanding, the IOC will work with the FOT directly to request the execution of a PROC or set of PROC's. The GBM Team pointed out that there would be very little required real-time commanding of the GBM. The most typical use of a PROC for GBM will be associated with instrument activation and contingency situations, and the number of required PROC's is not expected to be extensive. And they do not expect the command PROC's for the real-time commanding to be very complicated in terms of branching, IF-THEN-ELSE logic, etc.

(2) PROC Execution Requests

There was some discussion on potentially having the ability for the IOC to electronically request execution of a PROC that exists in the MOC. The PROC Execution Request would provide any needed PROC input parameters (which can be passed as parameters to the commands in the PROC). This would eliminate the need for the FOT to enter parameters when the PROC is executed, reducing the chances of error.

The GBM Team felt this capability would be useful for situations where a change in GBM was needed, but determination of the change has occurred after the pre-planned stored commands have been loaded on the spacecraft. The request would provide the FOT with a timeframe for when the PROC needs to be executed (e.g., some time during the current ops day). The FOT would only be able to act on one of these type of requests while the MOC is staffed (prime shift, 8x5). It was agreed that these requests would need to be infrequent and not be a daily routine way of commanding the instrument.

(3) RT Command Sequences

These requests are similar in function to the PROC Execution Requests, except that they provide a set of instrument commands to the FOT that the GBM Team would like executed. The RT Command Sequence would contain a list of instrument command mnemonics. They could not contain any spacecraft, LAT, or critical commands. The MOC would translate the command list to an executable PROC, with no logic, telemetry checks, etc. The request would provide information to the FOT on when the command set needs to be uplinked.

Two concerns the MOC has is that (1) technically the FOT would be executing a command PROC that has not been previously validated, and (2) that this method would become the normal way of commanding GBM, circumventing the operations concept of most all commanding being

preplanned days ahead of time. Tight constraints on what can be in the command sequences may resolve the first concern, and a solid ops agreement between the FOT and GBM Team the second. Further discussion needed. *[Post-mtg note: The critical thing to keep in mind here is that the operations concept and associated budget/staffing profile in the MOC requires that a large majority of the instrument commanding be performed in a preplanned manner (i.e., days ahead of time), and that shorter turn-around commanding be limited to special situations.]*

(4) Instrument Command Loads

These are stored, time-tagged commands that are integrated into the observatory ATS. They are placed into the spacecraft stored command processor, are executed on-board at a specified absolute time in the future, and can be spacecraft or instrument commands. The IOC must provide these loads a few days ahead of time so they can be integrated into the observatory ATS load by the MOC before load uplink.

It was discussed that typically ATS loads will need to span about 4 days to allow unattended operations to span a 3-day weekend. The FOT will likely uplink a new 4-day ATS load each workday, creating a sliding 4-day window. The GBM Team indicated that they would not be doing a lot of commanding via this method. See OPEN ITEMS.

A discussion ensued as to how the IOC specifies when the request should be executed. It was agreed that the request could be absolute time or event driven. An event is typically an orbital event, such as an equator crossing or SAA entry.

A discussion was held as to where the times should be assigned to event driven requests. The FOT feels that the MOC should be responsible for adding any time-tags required to the IOC requests in the actual stored command load to be uplinked. This ensures that the MOC is the one place that actually constructs all the bits that go into a stored command load. But the SSC will also need to assign time-tags to facilitate building the observation timeline. Both the SSC and MOC will have orbit propagators, so both can perform this function. But the MOC/FOT feels that the final timestamps need to put on by the MOC. See the OPEN ITEM on this topic.

There was discussion on exactly what was being provided to the SSC by the IOC, and subsequently by the SSC to the MOC in terms of actual commands vs. higher level activities. An activity would be a collection of commands that perform a function, similar to how Relative Time Sequences (RTS's) are used on the spacecraft. The activity would have parameters which could be passed to the appropriate commands as appropriate. The advantage with activities is that the users can just reference a predefined activity for frequently used functions. The disadvantage is that it adds another level of commanding and an increase in commanding complexity. It seemed like we were leaning towards limiting activities to the MOC to be used for FOT actions, and that the IOC's and SSC would deal only at the command level. See OPEN ITEM on this topic.

(5) Instrument Memory Loads

These are special loads where the GBM Team needs the MOC to uplink a memory load directly to the instrument. Typical memory loads would be table changes and flight software updates. The IOC would provide the SSC/MOC with the load itself, which the SSC and MOC would treat as a collection of bits that simply need to get to the instrument. Like stored command loads, memory loads are provided to the SSC and MOC way ahead of time (e.g., 2-3 days), except in emergencies.

Telemetry and Command Data Base Process/Approach

A lively discussion was held around the activities associated with the database. It was agreed that the following terminology should be used:

Instrument Telemetry & Command (T&C) Data Base- The instrument Housekeeping telemetry and command definitions, which are in AstroRT format for GBM.

Observatory Data Base- The combined Telemetry and Command (T&C) Data Bases for the spacecraft and instruments used for observatory I&T. Put together by Spectrum Astro. Instrument team provides the data base to Spectrum in AstroRT format.

Project Data Base- The T&C data bases used in the MOC for operations. Consists of the Observatory Data Base received from Spectrum and other FOT files that are needed for the MOC (e.g., definitions for ground station status packets). PDB is in ITOS format.

A great deal of discussion was centered around the fact that SAI is providing an AstroRT-based SIIS, whereas the MOC will use ITOS. The GBM Team plans to make heavy use of AstroRT for testing the instrument, so will be using AstroRT to process and view Housekeeping telemetry and AstroRT PROC's/scripts for doing commanding. This also means they will use AstroRT to build and manage the Instrument T&C Data Base. This AstroRT-formatted data base will be provided to Spectrum for observatory I&T. Spectrum will integrate the GBM, LAT and Spacecraft data bases into an Observatory I&T Data Base

It was agreed that the GBM IOC would migrate to ITOS for operations.
[Post-mtg note:: Project needs to provide the GBM Team with ITOS software and training. Should probably plan to have ITOS team visit the IOC to install ITOS and provide some training. GBM IOC with ITOS would need to be in place some time before launch so that it could be involved in the appropriate tests and ops sims. We need to get this on the schedule, and factor it into the ground system test plan.]

There was some discussion on the possibility of implementing a user interface capability to the ITOS-formatted PDB. Currently the FOT's on other ITOS-supported missions just use a text editor. An alternative discussed would be to use something like a Microsoft Access-based tool that would provide a nice user interface into the ITOS data base, some value-added syntax checking, The ground system/MOC team will look at the feasibility, etc. of adding this capability.

For the flow of data base files from the GBM IOC to the MOC, the following scenario was discussed. As mentioned, the GBM IOC would deliver the AstroRT-formatted data base files to Spectrum for observatory I&T. Spectrum would create an AstroRT-formatted Observatory T&C Data Base. From that data base Spectrum would create an ITOS-formatted Observatory T&C Bata Base and deliver to the MOC. The MOC would generate the PDB from the Observatory T&C Data Base and some FOT inputs. The ITOS-formatted PDB would be delivered to the BM IOC for use by the GBM IOC ITOS.

Discussed the process for validating the data base. It was agreed that the GBM Team is responsible for the contents of the GBM portion of the PDB, and will have to work with the FOT to validate that the data base is correct. This process is referred to as data base validation. Need to determine how this DB validation would actually be accomplished. See OPEN ITEMS.

Instrument/MOC Interface Definition

There was discussion on what kind of interfaces need to be defined between the instrument and the MOC. Clarified that the GBM IOC/MOC interface is covered by the GBM IOC/MOC ICD. This would cover the data exchanged between these two systems, but would not address the instrument/MOC interface.

It was agreed that the instrument/MOC interface items that need to be defined and documented are generally things the MOC needs to know to process instrument telemetry or send instrument

commands, excluding the definitions found in other documents (such as the 1553 Bus ICD and Instrument/spacecraft ICD's) or in the PDB. In discussions this seemed to mostly apply in the areas of how memory loads should be packaged by the MOC and provided to the instrument, and how the instrument will provide memory dumps to the MOC.

The Goddard ground system team proposed and the GBM Team agreed that the best place to document these interfaces would be the MOC to Observatory ICD (CDRL 4.2). Per the contract it is clear that this deliverable is an observatory-level ICD, i.e., should include the instruments. But it's not clear that there is a plan in place at Spectrum to get this information from the instrument teams and incorporate it into the CDRL. See OPEN ITEMS.

[Post-mtg note: For those interface items covered in some other document, they should still be addressed in the Observatory/MOC ICD, and then simply reference the document where they are covered. An example is the synch marker that the instruments need to add to the CCSDS packets for science telemetry going over the LVDS bus. The MOC needs to know about this because it is needed to extract packets from the VC stream out of the SSR. But the details are documented in the GBM Instrument/Spacecraft ICD.]

We also debated if the MOC should be required/able to extract instrument memory dumps from the instrument CCSDS packets, and then give the load to the IOC; or, if the MOC should just pass the packets on to the IOC for processing. If the MOC can extract the memory dumps, it provides the opportunity to take a look at the memory dump in the MOC without being dependent upon the IOC. And, the MOC needs this to be able to compare an instrument memory load and dump image to help determine if a load was successful, troubleshoot if a problem is being investigated, etc.
[Post-mtg comment from Mike R: Had same discussion with LAT IOC, and bottom line is that the MOC has to be able to extract instrument memory dump images so that they can be compared when needed to an instrument load image. The FOT cannot be dependent upon either IOC to do this for them, since they may not be available when needed, e.g., if FOT is doing work off-hours, or if link to IOC is down.]

Burst Alert Processors (BAP's) in MOC

A discussion was held to describe the generation and timing of the variety of messages created by the GBM FSW with respect to Burst Alerts. The critical points are that the GBM creates a record that simply tells the observatory that a burst has been seen. This allows the activation of the link through a TDRS. The next message will provide the initial location data. This process helps to ensure that the location data does not get lost during the establishment of the DAS link. Next, the instrument will constructed "better" location records based on longer time of observing the phenomenon. All of the records thus far described are sent to the GCN via the MOC.

The function of the GBM-IOC supplied software is to take GBM burst data and produce improved quality predictions of locations and burst characteristics. These improved products will be distributed to the GCN. It was agreed to refer to the system that performs this function as the Burst Alert Processor (BAP).

It was agreed that to avoid unnecessary complication of the ground system that the BAP will handle all burst messages from the GBM. It will simply throughput the originating burst messages. One side effect of this decision is that the MOC will have to let the IOC know if it detects that the BAP software is down or otherwise non-functional. In this case, the GBM IOC would forward all burst message it receives to the GCN.

The GBM team discussed the fact that they had a desire to provide even better localizations and burst characteristics to the community by allowing a person-in-the-loop mode of processing burst data within the GIOC. This would be in addition to what the BAP provides. There is a slight

concern that there may be an ITAR issue given the plan to use the mirror sites in Germany to extend the amount of time the humans would be available to the loop.

Discussion of timing associated with burst alert handling latency was purposely avoided, as it is still a system issue that is being worked at higher levels within the project.

Figure 2 below depicts the burst alert handling scenario discussed in the meeting.

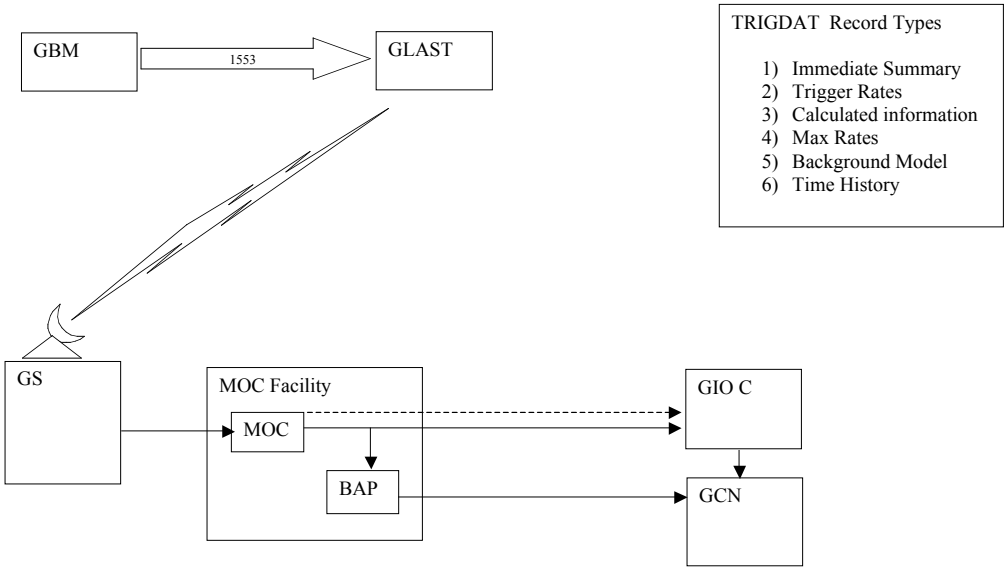

Figure 2 - Burst Alert Processing

Mnemonic Naming Convention

We discussed the notion of having a telemetry and command mnemonic naming convention. It was generally agreed we nee done. The GDS Project took an action to to look into where Spectrum was at with respect to this topic and take the lead on pushing this forward.

Scenario during L&EO

The GBM team agreed that they would be physically present with sufficient personnel to support the mission throughout the checkout period. The Project position that all operations would be supportable using only ITOS tools (page displays, graphics, etc) native to the MOC, was acceptable to the GBM team. The Project agreed that some specialized displays based on GBM GSE would be allowed as long that they were not critical to the success of any activity aboard the observatory.

There was also discussion of the ability to flow real-time data (i.e., Housekeeping packets) to the GBM team at the IOC (and to any IGSE they bring to the MOC during L&EO). It was determined that there were no pressing needs for this real-time data after the L&EO period. We agreed that long term the GBM IOC could just routinely access the housekeeping data offline which would be made available to outside users on a server by the MOC (as Level 0 data files, containing CCSDS packets).

OPEN ITEMS:

1. Need to come to a decision on if the electronic "PROC Execution Requests" and the "RT Command Sequences" are truly needed and can be supported by the MOC/FOT. The FOT's two primary concerns are:
   (1) Having an operations plan where the FOT is routinely being asked to respond to commanding requests with a quick (same day) turn-around since the ops concept (and FOT staffing) is based on commanding being very preplanned (2-3 days ahead of time).
   (2) For the RT Command Sequences, having PROC's created "on-the-fly" when the established process is to have all PROC's preapproved and tested.

Need some more discussion on these commanding methods.

2. Need to continue to work the concept of assigning time-stamps to ATS commands. For example, need to make sure that all components are using and recognizing the same orbital events. Where do they get documented? Is there a concern if the SSC and MOC are using different orbit propagators? If the MOC is going to also turn orbital events into time-stamps, how are the events associated with the commands or set of commands provided to the MOC by the SSS (and presumably by the IOC for test/contingency).

3. For stored commands, need to finalize definition of exactly what is exchanged among the IOC, SSC and MOC in terms of activities (collections of command mnemonics) vs. actual command mnemonics. One key driver seems to be to ensure that the SSC can perform science constraint checking, which may at times need to view on-board actions more at the activity level instead of the individual command level (i.e., needs to be able to see the forest and the trees).

4. Need to determine how we define the amount of flexibility for ATS stored commands in terms of when they execute. Typically there will be some level of flexibility in exactly when a stored command executes on-board. BY having some flexibility, the SSC and MOC will be better able to resolve any science or command level constraint violations. Also applies to the other commanding methods, such as when a PROC should be executed or when an instrument memory load should be uplinked.

5. Need to come to an operations agreement for how the GBM instrument will be routinely commanded. The operations concept and FOT staffing profile call for almost all routine commanding to be pre-planned (2 or more days ahead of time), and be via stored command loads and instrument memory loads. The GBM Team requested the option to also do some near real-time commanding (commands coming in the day they are needed on-board). This may be able to be handled, but only at an infrequent rate. Topic needs more discussion.

6. May need to consider implementing a command list builder in ITOS. Ground team needs to look into what ITOS has in this area, where it would help the user build a list of commands and command parameters, with the output being an ASCII or Excel-like file. AstroRt appears to have this capability, so should look into that as well.

7. Need to come up with a plan for how we will validate the GBM instrument portion of the Project Data Base in the MOC. The GBM team is responsible for "signing off" on the PDB, and the GBM Team and FOT will have to work together to get it validated.

8. Need to find out from Spectrum on if and how they plan to ensure that the instrument-to-MOC interfaces are covered in the Observatory/MOC ICD (CDRL 4.2).

9. Need to learn more from Spectrum about how commanding will be done in observatory I&T so that we can try to make the observatory I&T and operations environments as similar as possible. For example, we don't know how ATS loads will get built in observatory I&T in terms of incorporating instrument commands, or how instrument memory loads will be handled.